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MICROCLIMATE COOLING EFFECT ON TENSION/ANXIETY AND FATIGUE IN FIELD AND LABORATORY SETTINGS

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**Microclimate Cooling Effect on Tension/Anxiety
and Fatigue in Field and Laboratory Settings**

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SUMMARY

Problem.

U.S. Navy personnel stationed in the Persian Gulf work in an extremely high-heat and high-humidity environment. Exposure to heat has been shown to affect sleep quality, raise levels of tension/anxiety and fatigue, and cause decrements in performance capabilities and cognitive operations. Because many spaces on U.S. Navy ships cannot be efficiently air-conditioned, some form of microclimate cooling would be beneficial.

Objective.

The present study was designed to evaluate the psychological effects of wearing a cooling ice vest during watchstanding in the Persian Gulf. In order to evaluate the effects, subjects were given questionnaires to obtain repeated measures of tension/anxiety and fatigue. These measures were obtained prior to and following a watchstanding period during which the crew member was wearing an ice vest, and prior to and following another watchstanding period without wearing an ice vest. Subsequently, this field study was replicated in a laboratory setting using a heat chamber. The laboratory replication provided the opportunity to control some of the extraneous variables not controlled for in the field study.

Approach.

Forty-four volunteers from several duty stations in the Persian Gulf served as subjects in the field study. Approximately one-half of the subjects wore the ice vest on Day One of the study, and the other half wore the ice vest on Day Two, in this crossover study design. Subsequent laboratory replication was done with 11 subjects in which the effects of the extraneous variables of heat and humidity level and circadian cycles, among others, were controlled.

Results.

Field study subjects' tension/anxiety increased from pre- to post-watch without an ice vest, but tension/anxiety decreased during the watch when an ice vest was worn. Greater fatigue was reported following watchstanding without an ice vest than with an ice vest, however, the change in fatigue during watchstanding with the ice vest as opposed to without the ice vest was not statistically significant. The majority of subjects reported that the ice vest was helpful during watchstanding, that it did not interfere with their ability to do their job, and that they would recommend its future use.

Conclusions.

U.S. Navy personnel stationed in the Persian Gulf reported tension/anxiety is decreased by wearing an ice vest during watchstanding. Fatigue was not significantly changed after one watchstanding session with an ice vest; because of sleep problems among the crew, the level of fatigue was high, and therefore, the effect of the ice vest on fatigue may not be immediately observable. The results of this field study were corroborated under controlled conditions in a laboratory replication study. Results suggest that the availability of a passive microclimate cooling system (ice vest) would be beneficial for naval personnel deployed in high heat/humidity regions.

INTRODUCTION

Prolonged exposure to thermal stress in the form of high heat and humidity is a frequent problem for U.S. Navy personnel. In the Persian Gulf, site of naval operations supporting Desert Shield/Desert Storm, mean ambient temperatures ranged from 120° to 130°F, with an average relative humidity of 90% during the summer months. The Persian Gulf surface-water temperature is between 85° and 95°F, rendering shipboard air conditioning systems mostly inefficient. In addition to inefficient air conditioning, many spaces on U.S. Navy ships cannot be equipped to provide any form of air conditioned environment. The engine room on steam and diesel ships, for example, cannot be efficiently cooled because of the tremendous heat generated by the ship's engines.

Previous field studies of U.S. Navy ships operating in the heat of the Persian Gulf have shown crew members to experience: difficulty falling asleep, poor quality sleep, physical and psychological fatigue, falling asleep on the job, and feelings of confusion and tension/anxiety (Burr, Palinkas, Banta, Congleton, Kelleher, & Armstrong, 1989; Steele, Kobus, Banta, & Armstrong, 1989; Burr, Banta, Coyne, Hodgdon & Chesson, 1990). Exposure to heat has also been shown to affect performance capabilities during sustained work (Fine and Kobrick, 1987; U.S. Department of HEW, 1972). Grether (1973) reported that human performance of such tasks as time estimation, reaction time, vigilance, tracking, and other skilled cognitive operations show performance decrement in ambient temperatures above 85°F.

To relieve heat stress, one solution would be to provide individual cooling which could be accomplished by providing a crew member with some form of controlled microclimate. Most of the attempts to provide microclimate cooling have been achieved by circulating cool water or air through plastic tubes, either in a hood, the liner of a helmet, or in a body garment (Brooks, Hynes, Bowen, Allen and Kuehn, 1981; Shapiro, Pandolf, Sawka, Toner, Winsman, and Goldman, 1982; Nunneley and Maldonado, 1983; Pimental, Janik, and Avellini, 1988; Williams and Shitzer, 1974). Generally, the results of such controlled microclimate cooling studies have shown markedly reduced heat strain, as measured by subjective comfort, heart rate, core temperature, and state of dehydration (Gold and Zornitzer, 1968; Froese and Burton, 1957; Kissen, Hall, & Klemm, 1971; Nunneley, Troutman, & Webb, 1971).

Creation of a microclimate by air or water is only practical when a person's physical movement and mobility is limited. For example, aircraft or tank personnel could be outfitted with such equipment because their job does not require extensive movement in their work space. Additionally, the required apparatus such as self-contained water system, batteries, pumps, can be situated near the individual and/or attached to the aircraft/tank. Ships' crew members with jobs that require significant mobility could not complete their tasks while tethered to such a system. Therefore, an alternate cooling methodology, a passive cooling (ice) vest, has been designed, implemented, and tested (Pimental and Avellini, 1989) for use by crew members with jobs that require them to move about the ship while exposed to high heat stress.

The present study was designed to evaluate psychological effects of wearing a cooling ice vest during watchstanding in the high-heat environment of the Persian Gulf. In order to evaluate the effects, subjects were given questionnaires to obtain repeated measures of tension/anxiety and fatigue. These measures were obtained prior to and following a watchstanding period during which the crew member was wearing an ice vest, and prior to and following another watchstanding period without wearing an ice vest. Data analysis was designed to evaluate interaction effects, i.e., is the change in level of tension/anxiety and fatigue different during vest versus no-vest watchstanding. Subsequently, this field study was replicated in a laboratory setting using a heat chamber. The laboratory replication provided the opportunity to control some of the extraneous variables not controlled for in the field study. These variables were: heat and humidity level; circadian cycles; sudden shipboard schedule changes; opportunity for regularity in working, eating, and resting schedules; activity level; and the psychological effects of deployment.

METHODS

Study Subjects:

The subject population for the field study comprised 44 volunteers, officers, and enlisted personnel from several duty stations in the Persian Gulf. Two U.S. Navy ships, an auxiliary ship categorized as a Miscellaneous Command Ship (AGF), and a Minesweeper (MSO) contributed 24 subjects. Other field study subjects included personnel stationed on an oil barge in the Persian

Gulf (N = 6), a patrol boat (N = 5), and a shore-based security support unit (N = 9). Ages in the field study sample ranged from 18 to 43 years with a mean age of 26.6 years.

The subject population for the laboratory replication portion of this study were 11 enlisted volunteers stationed on the submarine base at Point Loma, San Diego, California. Ages of these subjects ranged from 19 to 27 with a mean age of 23.0 years. All subjects were informed of the study objectives, methods, and risks, and all gave informed consent.

Measures:

Environment Measures. A thermal stress index used in both military and civilian applications, is the Wet Bulb Globe Temperature (WBGT) index. WBGT is obtained with an electronic meter that independently measures the dry bulb, wet bulb, and globe (radiant) temperatures. The instrument displays each of these values as well as computes and displays the WBGT index in degrees Fahrenheit (NAVMED-P-5010-3, 1988).

Psychological Measures. Study subjects were administered the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971) Tension/Anxiety (POMS-TA) and Fatigue (POMS-F) subscales. These scales consist of descriptive terms that subjects rate for occurrence (see Appendix A). The POMS has been extensively used in studies of moods and mood change, and its reliability and validity are well-documented (Lefcourt, Martin, & Saleh, 1984).

Subjective Ice Vest Opinion Survey. Study participants were also given a short questionnaire designed to allow them to provide input concerning the comfort, design, and usefulness of the ice vest.

Physiological Measures. A variety of physiological measures (heart rate, rectal temperature, skin temperature at various sites, blood pressure, urine analysis, blood constituent analysis) were taken during experimental sessions. Assessment of the ice vest effect on these physiological measures is beyond the scope of this study and therefore will be addressed in subsequent technical reports.

Materials:

The ice vest, manufactured by Steele, Inc. of Kingston, Washington, covered the upper body from the shoulders to the waist. On the front and back sides, there were three horizontal

compartments, or pockets, that went across the entire width of the vest; a gel thermostrip (package of ice) was inserted into each of these six compartments. The total weight of the vest and thermostrips was approximately 12 pounds.

Procedure:

Field Study. Circadian cycles were not controlled nor was the daily shipboard routine altered to accommodate the field study. On two consecutive days, subjects were asked to report to a "ready room" where the POMS-TA and POMS-F subscales were administered prior to their four-hour watch. The subjects were then instrumented to obtain the physiological measures (heart rate, skin, and core temperature) which were continuously collected on a portable, solid-state recording device. Subjects served as their own controls in this crossover study design. Approximately half of the subjects wore the ice vest on Day One of the experiment and the other half wore the ice vest on Day Two. Subjects then reported to their work station and stood a routine four-hour watch. Work stations included the engine room, various topside positions on the AGF, MSO, and patrol boat deck, the oil barge platform, and standing guard at the shore-based security support unit. WBGT at these work stations ranged from 86°F to 100°F, with an average WBGT of 92.4°F. Relative humidity ranged from 52% to 71%, with an average relative humidity of 62%. Two hours into the watch, a member of the research team brought fresh thermostrips to the subjects wearing ice vests, and replaced the thawing thermostrips. When the watch was completed, subjects returned to the "ready room" and were again administered the tension/anxiety and fatigue scale portions of the questionnaire.

Laboratory Study. Subjects were transported to the laboratory where they were housed during the study period. Circadian cycles were controlled by providing a constant eight hours of rest per night (lights out at 10 p.m., lights on at 6 a.m.). Subjects were transported to the heat chamber where they were prepared for the physiological measures and given the POMS questionnaire. As in the field study, half of the subjects wore the ice vest on Day One of the experiment and the other half wore the ice vest on Day Two. Subjects then entered a chamber heated to a WBGT of 97°F with the relative humidity at 45%, where they stood a simulated four-hour engine room watch.

Data Analysis:

Data obtained from personnel who were tested pre- and post-watch, with and without an ice vest, were analyzed using repeated measures multivariate analysis of variance (MANOVA). The hypothesis being tested was the same in both the field and laboratory portions of this study; that the change in tension/anxiety and fatigue scale scores would show a different pattern for watchstanding while wearing an ice vest than for watchstanding without an ice vest. In the field study, an important consideration when comparing the vest and no-vest session measures of tension/anxiety and fatigue is the thermal stress index during the two days the subject was tested. A matched pair t-test showed no significant difference between WBGTs (92.3°F and 92.5°F) for the 44 field study subjects during the vest and no-vest watchstanding sessions.

RESULTS

Repeated measures MANOVA were conducted to evaluate changes in tension/anxiety and fatigue during watchstanding with and without an ice vest. The relationship of interest is the vest by time interaction which compares the change in the level of tension/anxiety from pre- to

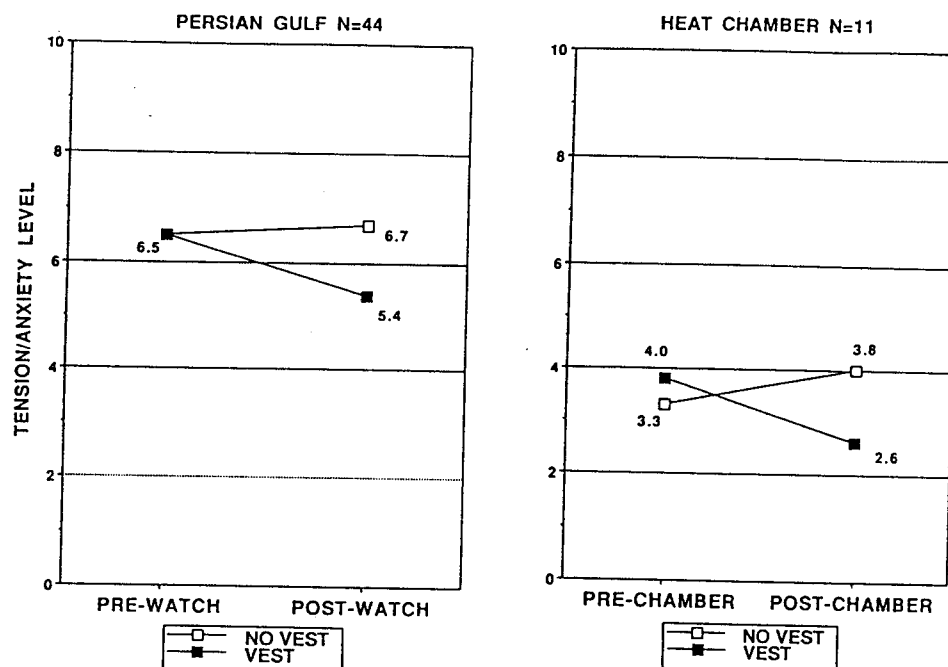


Figure 1. Mean POMS-TA by vest condition from pre- to post-watch.

post-watch during ice vest and no-ice vest watchstanding sessions. The results of the MANOVA on the POMS-TA scale showed significant vest by time interactions in both the field study ($F[1,42] = 4.84, p < .03$), and in the laboratory study ($F[1,10] = 7.30, p < .03$). The pattern of the interactions (see Figure 1) showed that tension/anxiety increased from pre- to post-watch in the no-vest condition, but decreased during the watch when an ice vest was worn.

The MANOVA on POMS-F did not show a significant interaction (see Figure 2). Fatigue increased during the watch in both vest and no-vest conditions. Watchstanders reported greater fatigue after the no-vest watch than after their vest watch, however, the change in fatigue during watchstanding with an ice vest as opposed to without an ice vest was not statistically significant.

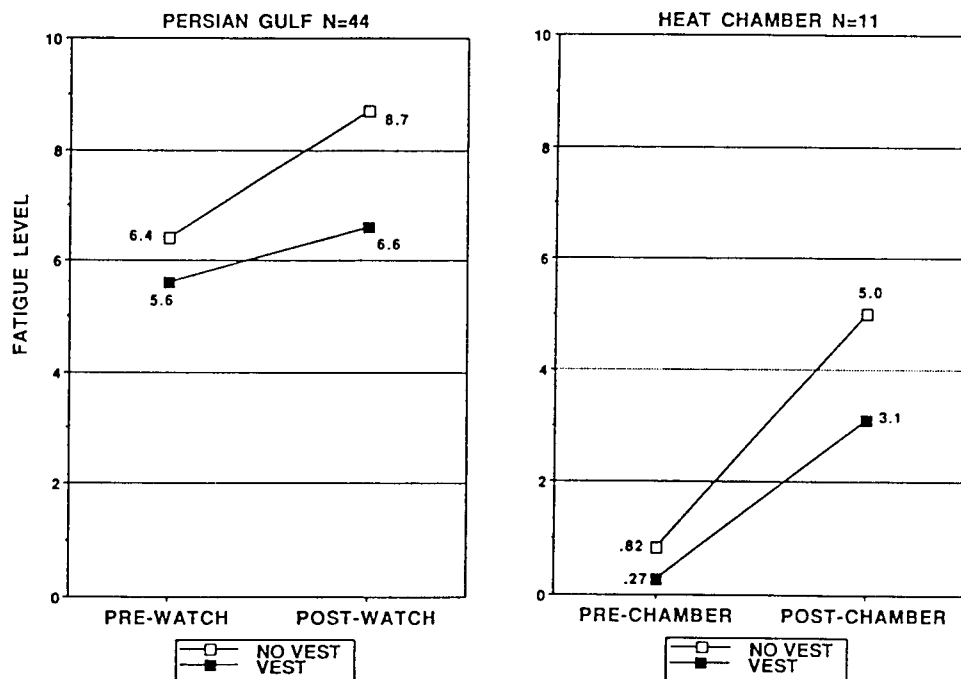


Figure 2. Mean POMS-F by vest condition from pre- to post-watch.

Another notable result revealed by the figures is the distinctively higher pre-watch level of tension/anxiety, and of fatigue, in the field study when compared with the pre-chamber level of these psychological measures in the laboratory replication. The Persian Gulf subjects and the heat chamber subjects started their experimental sessions at very different levels of tension/anxiety and fatigue, however, the pattern of change from pre-to post-watch was very similar for field and laboratory heat-exposure sessions.

Results obtained from the vest survey showed that all of the subjects in both parts of the study (N=55; Persian Gulf N=44, laboratory study N=11) felt the ice vest was at least "somewhat helpful" to their ability to perform and stand a normal watch; 62% of the subjects responded that the ice vest was "very helpful" or "extremely helpful." When asked if wearing the ice vest interfered with the performance of their job, 36% felt that there was "no interference," 36% said there was "some interference," and 26% said there was "moderate interference." When asked if they would recommend that their ship obtain ice vests for future use on watchstations under high heat conditions, 53 of the 55 subjects reported that they would recommend implementation of an ice vest.

DISCUSSION

This study examined the psychological effects of wearing a cooling ice vest during watchstanding in the high heat and humidity of the Persian Gulf region. The results of this field study were corroborated under controlled conditions in a laboratory replication study. It was hypothesized that providing a cool microclimate would decrease feelings of tension/anxiety and fatigue. In the field and the lab, results showed a significant difference in the tension/anxiety level from pre- to post-watch when wearing an ice vest as opposed to not wearing one. The same effect was not found for fatigue. It may be that the effects of the ice vest on tension/anxiety are more immediate, while the effects on fatigue are more cumulative. Thus, it may take several watchstanding sessions while wearing a cooling vest for a measurable effect to be found for fatigue. This conclusion is supported by other data collected from the subjects which indicated that 70% of the sample were having trouble falling asleep. Problems with sleep could cause an ongoing feeling of fatigue that may not be significantly affected by a single four-hour session with an ice vest. In the laboratory study, sleep problems were not reported and

pre-chamber level of fatigue was much lower than pre-watch fatigue in the field study. Under these conditions the ice vest effect on fatigue approached statistical significance ($p < .07$).

Responses to the vest survey indicated that wearing the ice vest was helpful in performing and standing a normal watch. It did not interfere with the performance of the job and the subjects recommended that their ship obtain and make ice vests available for future use. This endorsement from the users of the ice vest, along with the finding that tension/anxiety are significantly reduced during watchstanding when an ice vest was worn, supports the idea that a passive microclimate system, such as an ice vest, be made available to U.S. Navy crew members deployed in high heat and humidity regions.

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APPENDIX A

<u>Tension/Anxiety Items</u>	<u>Fatigue Items</u>
Tense	Worn out
Shaky	Listless
On Edge	Fatigued
Panicky	Exhausted
Relaxed	Sluggish
Uneasy	Weary
Restless	Bushed
Nervous	
Anxious	

Response alternatives given

- 0 = not at all
- 1 = a little
- 2 = moderately
- 3 = quite a bit
- 4 = extremely

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13. ABSTRACT (Maximum 200 words) Crew members aboard U.S. Navy ships in the Persian Gulf work under high-heat and high-humidity conditions. Exposure to heat has been shown to affect sleep quality, and to cause tension, anxiety, and fatigue, and to decrease performance capabilities and cognitive operations. Because many ship spaces cannot be air conditioned, a microclimate cooling system was tested as an alternative. Objectives of this study were to measure and compare levels of tension/anxiety and fatigue in subjects during watchstanding sessions, with and without a cooling ice vest. There was a statistically significant effect on tension/anxiety; subjects had an increase in tension/anxiety from pre-watch to post-watch in the no-ice vest condition, but tension/anxiety decreased during the watch when an ice vest was worn. The change in fatigue during watchstanding with the ice vest and without was not statistically significant. A subsequent laboratory replication of this Persian Gulf field study corroborated these results. The majority of the subjects in both the field and laboratory portions of this study reported that the ice vest was helpful during watchstanding, that it did not interfere with their ability to do their job, and that they would recommend future use of the ice vest. The results of this study suggest that a passive microclimate cooling system (ice vest) would be beneficial				
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for the mood and comfort of naval personnel deployed in high heat/humidity regions.